

Greenhouse effect

Anthropic or natural?

As already mentioned in the previous paragraphs, the greenhouse effect is a natural phenomenon, provoked by a mixture of gases that are present in the atmosphere (and defined greenhouse gases) without which there would not be any life on the Earth. In the last century, however, the intense human production activities led to an increase in the concentration of "greenhouse gases" in the atmosphere. There are two main causes: on one hand the increasing amount of emissions originated prevalently by the traditional processes for the production of energy (fossil fuels); on the other, the progressive destruction of the forests which, thanks to plant chlorophyll photosynthesis, can "absorb" the carbon dioxide in the air and transform it into organic material (leaves, branches and roots), acting as true "tanks" or "sinks" for carbon dioxide. If the concentration of greenhouse gases continues to increase at the rhythm of the last decades, there is the risk that a rapid warming in the Earth's climate may be triggered, because the capacity of the atmosphere to hold back the heat on the Earth is increasing progressively. An excessive increase in a short period of time, of the temperatures of the atmosphere and of the oceans, would have dramatic effects on the climate balance and a remarkable impact on human beings.

According to some climate experts, if human behaviour does not change, in the next 100 years the Earth's temperature may increase an average of 1.0 to 3.5°C. Other data give us an indication of the variations which occurred in the past century: from the industrial revolution to date, the concentration of carbon dioxide in the atmosphere has increased 30%, during the same period the concentration of methane, emitted principally by the rice fields and cattle farms, has increased 145%. Many experts, appointed by national and international organizations, among which IPCC (Intergovernmental Panel on Climate Change) have, since some years, been monitoring the climate of our planet and studying the possible effects of the increase in temperature of the lower atmosphere and of the Earth's surface, which will be examined in detail in the following paragraph.

Consequences of climate changes

Based on the researches of the International Organism that studies climate changes, IPCC (Intergovernmental Panel on Climate Change), the increase in the concentrations of greenhouse gas in the atmosphere is the main cause of the intensification of the following phenomena:

- Increase in Planet temperature: from 1860 to date, the Earth's average temperature has increased 0.6°C and almost 1°C in Europe alone. Scientists have estimated a further increase in the temperature ranging between 1.4°C and 5.8°C by the end of the century.
- Increase in the precipitation: mainly in the Northern Hemisphere, and in particular in the middle and high latitudes. In the tropical and subtropical regions, instead, a decrease in the amount of rain.
- Increase in the frequency and intensity of extreme climatic events: there still are no scientific data to demonstrate this point, however one of the consequences of climate changes apparently seems to be the increase in catastrophic events. In fact there may be long periods of draught, sudden exceptional rainfall, floods, waves of excessive heat and cold. Tropical cyclones may be strengthened by violent rainfall, winds and the sea level.
- Increase in the risk of desertification in some areas.
- Decrease in the glaciers and permafrost: 9 glaciers out of 10 in the world are melting, and it is probable that by 2050, 75% of the Swiss glaciers will have disappeared.
- Rise in the sea level: during the last 100 years, the sea level increased 10-25 cm and it seems that it might increase 88 cm more by 2100. At least 70 million inhabitants in the coastal areas of Europe may be at risk.

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- Loss of biodiversity: many animal species will not be able to adapt to these rapid climate changes. In fact experts have established that ecosystems can adapt to changes amounting to 1°C in a century. Among the animals that are most endangered, we find the polar bears, seals, walruses and penguins
- Problems in food production: with excessive rainfall and intense heat, cultures are at risk, and famine and malnutrition follow. FAO has estimated that there will be a loss of approximately 11% of the land that is fit for cultivation in the developing countries by 2080, with a decrease in the production of cereals and a consequent increase in world hunger.
- Diffusion of diseases: it seems that climate change can favour the diffusion of tropical diseases such as malaria and dengue. In fact the mosquitoes that carry these diseases are shifting north, where the temperature is rising. Furthermore an increase in temperature favours the biological pollution of water, which leads to a proliferation of infesting organisms.

Greenhouse gases

Natural greenhouse gases include water vapour, carbon dioxide, methane, nitrogen protoxide and nitrogen. Some human activities contribute to the increase in the concentration of these gases in the atmosphere and, furthermore, they free other greenhouse gases that are exclusively anthropogenic in the air.

Let us now examine the characteristics of the principal gases which have a greenhouse effect, in detail:

Water vapour

Water vapour is the principal greenhouse gas, it is responsible for 2/3 of the natural greenhouse effect, due to its abundance in the atmosphere and due to its efficacy. Atmospheric water vapour is part of the water cycle, a closed system of water circulation from the oceans and the continents to the atmosphere in a continuous cycle of evaporation, transpiration, condensation and precipitation. Its concentration is very variable in space, but relatively stable in time. Furthermore it is not directly influenced by human activities, but depends exclusively on the air temperature. For every degree Celsius more, the content of water vapour in the air increases 7%.

Carbon dioxide

Carbon dioxide (CO₂) is the principal greenhouse gas deriving from human activities, and it is the one that contributes most to the anthropic greenhouse effect.

CO₂ is one of the main compounds of carbon and is the principal vehicle for carbon exchange in nature between reservoirs (or pools) that are present in the atmosphere, hydrosphere, geosphere and biosphere, through processes that form the carbon cycle:

- in the biosphere, carbon is present in organic molecules (e.g. lipids, glucides, etc.) amounting to about 2,000 billion tons or gigatons;
- in the oceans, carbon is dissolved in the form of carbonates and bicarbonates, amounting to about 39,000 gigatons;
- in the geosphere, carbon can be found in the form of limestone, amounting to 90,000,000 gigatons and fossil fuel amounting to 6,000 gigatons;
- in the atmosphere, carbon is found in the form of carbon dioxide, amounting to 750 gigatons.

These reservoirs are tied to each other by exchanges, and their natural balance, in absence of human activities, is practically equal. Starting from the Industrial Revolution, with the intensification of human activities, the concentrations of carbon dioxide in the atmosphere increased, and today CO₂ is responsible for 65% of the anthropic greenhouse effect. The carbon dioxide deriving from human activities is tied principally to the fossil fuels combustion reaction, to deforestation and changes in land use. CO₂ can persist in the atmosphere for a period that varies between 50 and 250 years before returning to the ground.

Methane

Methane (CH_4) is derived from anaerobic fermentation (i.e. from decomposition) of organic substances. In nature, methane is emitted by mangrove swamps, while the anthropogenic emissions derive mainly from the use of fossil fuels, animal farming, agriculture (paddy fields) and city dumps. Even though it is more powerful than CO_2 , methane contributes to 17% of the anthropic greenhouse effect due to the minor concentration and the shorter period in which it remains in the atmosphere, compared to carbon dioxide.

Nitrogen protoxide

Nitrogen protoxide (N_2O) is a very powerful greenhouse gas, with a very long time of persistence in the atmosphere (120 years). Natural sources of N_2O are the oceans, the rainforests and the bacteria that are present in the ground. With regard to human activities, instead, it derives mainly from nitrogen fertilizers used in agriculture and some industrial productions.

Chlorofluorocarbons

Chlorofluorocarbons or CFC, unlike the gases described here above, which can all be found in nature, are produced artificially by humans and used as refrigerants, spray bottle propellants, and fire extinguishers.

Besides being responsible for destroying the ozone in the stratosphere (Ozone Hole) they are powerful greenhouse gases and they persist in the atmosphere for thousands of years. Their emissions have been remarkably reduced with the application of the Montreal Protocol (1987) which prohibited their use. However even the gases that they have been replaced with (hydrofluorocarbons and perfluorocarbons) are powerful greenhouse gases.

Comparing greenhouse gases

In order to calculate the contribution of the different gases to the greenhouse effect, three fundamental parameters must be taken into consideration:

- concentration in the atmosphere;
- radiative forcing of each gas, i.e. the capacity to trap the energy going from our Planet into Space;
- persistence in the atmosphere of each gas, i.e. the mean time the gas remains in the atmosphere; in fact if a gas remains in the atmosphere for a short period of time it will have a lesser effect than a gas that remains for a long period of time.

Since the greenhouse gases have various capacities of absorbing infrared radiations, the concept of Global Warming Potential (GWP) has been introduced. Therefore all the gases are compared to carbon dioxide, which has been assigned a potential = 1.

When the greenhouse effect "born"

In 1824 the French scientist Jean Baptiste Fourier, who made some famous discoveries in physics and mathematics, was the first one to talk about "greenhouse effect" and measure it with the helium thermometer. The theory is that the atmosphere acts as the glass enclosure of a greenhouse, which lets solar rays through while it tends to trap the thermal rays which are released by the planet's surface. Thanks to this, Earth's average temperature is stable around 15°C , instead of approximately the -19°C that it would be without "greenhouse gasses". The greenhouse effect is a natural phenomenon which happens on all planets that have an atmosphere. Thus the problem arises from the atmospheric composition which can increase or decrease its effects.

In 1895, about 150 years after the Industrial Revolution the Swedish scientist Svante Arrhenius was able to understand that the increase of carbon dioxide (CO_2) in the atmosphere, was going to eventually bring about a global warming of the Planet. In 1955 Charles Keeling confirmed that carbon dioxide levels were rising to the point that an actual observatory was set up in Hawaii to keep track of the concentration of this gas in the atmosphere.

At the end of the 80's the United Nations created a committee of experts called IPCC (Intergovernmental Panel on Climate Change) to classify and analyze the results coming from the different studies.

What is the IPCC?

Since the end of the Eighties, scientists have become aware that the great amount of human-induced greenhouse gas emissions was causing an increase in the greenhouse effect, and consequently, significant changes in climate which could trigger many problems. In order to have a clearer and more thorough knowledge of the situation, the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) created the **IPCC**, the *Intergovernmental Panel on Climate Change*, in 1988 with the intention of providing “a clear scientific view on the current state of knowledge in climate change and its potential environmental and socio-economic impacts”. The IPCC is an intergovernmental body which the member countries of both the UNEP and the WMO have joined. It does not involve carrying out direct research but rather assessments. So what does it do exactly? The IPCC aims at collecting and summarising all relevant information available to better understand the phenomenon of climate change and its possible impacts; in particular, the risks to human health associated with climate change, as well as the possible response strategies to be implemented, such as adaptation and mitigation. These measures, put forward by the scientific community worldwide, are carefully checked by hundreds of experts that ensure the validity of the information collected. Each participating government has a designated Focal Point IPCC, whose task is to coordinate the activities in the country. The importance of this project was recognised in 2007 when IPCC and Albert (Al) Gore Jr. were awarded the Nobel Peace Prize for “their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change”

The IPCC è divided into three working groups (**WG**) and a task force:

- WG I assesses the climate system from a physical point of view;
- WG II assesses the vulnerability of natural and socio-economic systems, the impacts of climate change and the possible adaptation options;
- WG III assesses options for mitigating climate change and proposes economic evaluations;
- the Task Force on National Greenhouse Gas Inventories oversees the IPCC National Greenhouse Gas Inventories Programme which aims to develop and refine an internationally agreed methodology and software for the calculation and reporting of national greenhouse gas emissions.

Once a year the Panel meets in plenary session to adopt all official decisions such as the approval of reports and the definition of future work projects.

Hence the main task of the IPCC is to periodically produce an Assessment Report (AR) which contains the state-of-the-art of the most significant literature put forward by scientists in the field of climate change. The Assessment Report is divided into three parts, one for each Working Group. The first report was published in 1990, the second in 1995, the third in 2001 and the fourth in 2007. The Fifth Assessment Report was published in 2014; it was completed in April 2014. Besides the Assessment Reports, the IPCC also prepares Special Reports and Technical Papers, which even provide scientific support to the United Nations Framework Convention on Climate Change – UNFCCC.